

PROBLEMS

1. (a) $K_{sp} = [\text{Co}^{3+}]^2[\text{S}^{2-}]^3$ (b) $K_{sp} = [\text{Pb}^{2+}][\text{Cl}^-]^2$
 (c) $K_{sp} = [\text{Zn}^{2+}]^2[\text{P}_2\text{O}_7^{4-}]$ (d) $K_{sp} = [\text{Sc}^{3+}][\text{OH}^-]^3$
3. (a) $\text{Hg}_2\text{Cl}_2(s) \rightleftharpoons \text{Hg}_2^{2+}(aq) + 2\text{Cl}^-(aq)$ (b) $\text{PbCrO}_4(s) \rightleftharpoons \text{Pb}^{2+}(aq) + \text{CrO}_4^{2-}(aq)$
 (c) $\text{MnO}_2(s) \rightleftharpoons \text{Mn}^{4+}(aq) + 2\text{O}^{2-}(aq)$ (d) $\text{Al}_2\text{S}_3(s) \rightleftharpoons 2\text{Al}^{3+}(aq) + 3\text{S}^{2-}(aq)$
5. (a) $[\text{OH}^-]^2 = \frac{2.5 \times 10^{-14}}{1.5 \times 10^{-6}} = 1.67 \times 10^{-8}$; $[\text{OH}^-] = 1.3 \times 10^{-4} M$
 (b) $[\text{Cu}^{2+}]^3 = \frac{7.6 \times 10^{-36}}{(2.4 \times 10^{-4})^2} = 1.3 \times 10^{-28}$; $[\text{Cu}^{2+}] = 5.1 \times 10^{-10} M$
 (c) $[\text{Zn}^{2+}] = \frac{2.7 \times 10^{-8}}{8.8 \times 10^{-3}} = 3.1 \times 10^{-6} M$
7. (a) $[\text{Pb}^{2+}] = \frac{K_{sp} \text{ PbBr}_2}{[\text{Br}^-]^2} = \frac{6.6 \times 10^{-6}}{(0.019)^2} = 0.018 M$
 (b) $[\text{Hg}_2^{2+}] = \frac{K_{sp} \text{ Hg}_2\text{Br}_2}{(0.019)^2} = \frac{6 \times 10^{-23}}{(0.019)^2} = 2 \times 10^{-19} M$
 (c) $[\text{Ag}^+] = \frac{5 \times 10^{-13}}{0.019} = 3 \times 10^{-11} M$
9. (a) $1 \times 10^{-10} = [\text{Co}^{2+}][\text{CO}_3^{2-}]$; $[\text{Co}^{2+}] = [\text{CO}_3^{2-}] = 1 \times 10^{-5} M$
 (b) $2 \times 10^{-19} = [\text{La}^{3+}][\text{F}^-]^3$; $[\text{La}^{3+}] = \frac{2 \times 10^{-19}}{(7 \times 10^{-6})^3} = 6 \times 10^{-4} M$
 (c) $6 \times 10^{-39} = [\text{Ba}^{2+}]^3[\text{PO}_4^{3-}]^2$; $[\text{PO}_4^{3-}]^2 = \frac{6 \times 10^{-39}}{(4.2 \times 10^{-8})^3}$; $[\text{PO}_4^{3-}] = 9 \times 10^{-9} M$
11. (a) $[\text{Ba}^{2+}] = \frac{K_{sp} \text{ BaF}_2}{[\text{F}^-]^2} = \frac{1.8 \times 10^{-7}}{(0.025)^2} = 2.9 \times 10^{-4} M$
 (b) $[\text{F}^-]^2 = \frac{1.8 \times 10^{-7}}{0.0045}$; $[\text{F}^-] = 6.3 \times 10^{-3} M$
 $\% \text{ F}^- \text{ left} = \frac{6.3 \times 10^{-3}}{2.5 \times 10^{-2}} \times 100\% = 25\%$; $\text{F}^- \text{ precipitated} = 75\%$

$$13. [\text{Ca}^{2+}] = \frac{3.0 \times 10^{-3} \text{ g/L}}{40.08 \text{ g/mol}} = 7.5 \times 10^{-5} M$$

$$[\text{SO}_4^{2-}] = \frac{5.0 \times 10^{-4} \text{ g/L}}{142.1 \text{ g/mol}} = 3.5 \times 10^{-6} M$$

$$Q = (7.5 \times 10^{-5})(3.5 \times 10^{-6}) = 2.6 \times 10^{-10} < 7.1 \times 10^{-5}; \quad \text{no}$$

$$[\text{SO}_4^{2-}] = \frac{7.1 \times 10^{-5}}{7.5 \times 10^{-5}} = 0.95 M$$



$$(a) \text{mol Hg}_2^{2+} = \text{mol Hg}_2\text{Cl}_2 = (0.01300 \text{ L})(0.0021 \text{ mol/L}) = 2.7 \times 10^{-5}$$

$$[\text{Hg}_2^{2+}] = \frac{2.7 \times 10^{-5} \text{ mol}}{0.013 \text{ L} + 0.025 \text{ L}} = 7.4 \times 10^{-4} M$$

$$\text{mol Cl}^- = \text{mol HCl} = (0.0250 \text{ L})(0.015 \text{ mol/L}) = 3.8 \times 10^{-4}$$

$$[\text{Cl}^-] = \frac{3.8 \times 10^{-4} \text{ mol}}{0.013 \text{ L} + 0.025 \text{ L}} = 9.9 \times 10^{-3} M$$

$$Q = [\text{Hg}_2^{2+}][\text{Cl}^-]^2 = (7.4 \times 10^{-4})(9.9 \times 10^{-3})^2 = 7.2 \times 10^{-8} > 1 \times 10^{-18}; \quad \text{yes}$$

(b) Before reaction, there are $3.8 \times 10^{-4} \text{ mol Cl}^-$ and $2.7 \times 10^{-5} \text{ mol Hg}_2^{2+}$.

$2.7 \times 10^{-5} \text{ mol Hg}_2^{2+}$ will react with $2(2.7 \times 10^{-5}) = 5.4 \times 10^{-5} \text{ mol Cl}^-$.

Hg_2^{2+} is limiting and used up. $\text{mol Cl}^- \text{ left} = 3.8 \times 10^{-4} - 5.4 \times 10^{-5} = 3.3 \times 10^{-4}$

$$[\text{Cl}^-] = \frac{3.3 \times 10^{-4} \text{ mol}}{0.013 \text{ L} + 0.025 \text{ L}} = 8.7 \times 10^{-3} M$$

$$\text{mol NO}_3^- = 2(\text{mol Hg}_2(\text{NO}_3)_2) = 2(2.7 \times 10^{-5}) = 5.4 \times 10^{-5}$$

$$[\text{NO}_3^-] = \frac{5.4 \times 10^{-5} \text{ mol}}{0.013 \text{ L} + 0.025 \text{ L}} = 1.4 \times 10^{-3} M$$

$[\text{Hg}_2^{2+}]$ after equilibrium with the precipitate is established:

$$1 \times 10^{-18} = [\text{Hg}_2^{2+}][\text{Cl}^-]^2 = [\text{Hg}_2^{2+}][8.7 \times 10^{-3}]^2; \quad [\text{Hg}_2^{2+}] = 1 \times 10^{-14} M$$

17. let s = molar solubility of the solid

$$(a) [\text{PbCl}_2] = s; \quad [\text{Pb}^{2+}] = s; \quad [\text{Cl}^-] = 2s$$

$$1.7 \times 10^{-5} = [\text{Pb}^{2+}][\text{Cl}^-]^2 = (s)(2s)^2; \quad s = 0.016 M = [\text{PbCl}_2]$$

$$(b) [\text{Ca}_3(\text{PO}_4)_2] = s; \quad [\text{Ca}^{2+}] = 3s; \quad [\text{PO}_4^{3-}] = 2s$$

$$1 \times 10^{-33} = (3s)^3(2s)^2; \quad s = 1 \times 10^{-7} M = [\text{Ca}_3(\text{PO}_4)_2]$$

$$(c) [\text{Ag}_2\text{CO}_3] = s; \quad [\text{Ag}^+] = 2s; \quad [\text{CO}_3^{2-}] = s$$

$$8 \times 10^{-12} = (2s)^2(s); \quad s = 1 \times 10^{-4} M = [\text{Ag}_2\text{CO}_3]$$

19. (a) $K_{sp} = [\text{Zn}^{2+}][\text{CO}_3^{2-}]$; $[\text{Zn}^{2+}] = [\text{CO}_3^{2-}] = [\text{ZnCO}_3] = 1.21 \times 10^{-5}$

$$K_{sp} = (1.21 \times 10^{-5})(1.21 \times 10^{-5}) = 1.46 \times 10^{-10}$$

(b) $K_{sp} = [\text{Ag}^+]^2[\text{SO}_4^{2-}]$; $[\text{SO}_4^{2-}] = [\text{Ag}_2\text{SO}_4] = 0.014 \text{ M}$; $[\text{Ag}^+] = 2[\text{SO}_4^{2-}] = 0.028 \text{ M}$

$$K_{sp} = (0.028)^2(0.014) = 1.1 \times 10^{-5}$$

(c) $K_{sp} = [\text{Sr}^{2+}]^3[\text{PO}_4^{3-}]^2$; $[\text{Sr}^{2+}] = 3[\text{Sr}_3(\text{PO}_4)_2] = 3(2.5 \times 10^{-7} \text{ M}) = 7.5 \times 10^{-7} \text{ M}$

$$[\text{PO}_4^{3-}] = 2[\text{Sr}_3(\text{PO}_4)_2] = 2(2.5 \times 10^{-7} \text{ M}) = 5.0 \times 10^{-7} \text{ M}$$

$$K_{sp} = (7.5 \times 10^{-7})^3(5.0 \times 10^{-7})^2 = 1.1 \times 10^{-31}$$

21. $\text{AgCl}(s) \rightleftharpoons \text{Ag}^+(aq) + \text{Cl}^-(aq)$ $K_{sp} = 1.8 \times 10^{-10}$

Let s = molar solubility of $\text{AgCl} = [\text{AgCl}]$; $s = [\text{Ag}^+] = [\text{Cl}^-]$

(a) $1.8 \times 10^{-10} = (s)(s)$; $s = 1.3 \times 10^{-5} \text{ M} = [\text{AgCl}]$; $(1.3 \times 10^{-5} \text{ mol/L})(143.4 \text{ g/mol}) = 0.0019 \text{ g/L}$

(b) $[\text{Cl}^-]$ from $\text{AgCl} = s$; $[\text{Cl}^-]$ from $\text{BaCl}_2 = 2[\text{BaCl}_2] = 2(0.025) = 0.050 \text{ M}$

$$[\text{Cl}^-] = s + 0.050$$
 Assume $s \ll 0.050$; $[\text{Cl}^-] = 0.050 \text{ M}$

$$1.8 \times 10^{-10} = (s)(0.050)$$
; $s = 3.6 \times 10^{-9} \text{ M}$; $(3.6 \times 10^{-9} \text{ mol/L})(143.4 \text{ g/mol}) = 5.2 \times 10^{-7} \text{ g/L}$

(c) $[\text{Ag}^+]$ from $\text{AgCl} = s$; $[\text{Ag}^+]$ from $\text{AgNO}_3 = [\text{AgNO}_3] = 0.17 \text{ M}$

$$[\text{Ag}^+] = s + 0.17$$
 Assume $s \ll 0.17$; $[\text{Ag}^+] = 0.17 \text{ M}$

$$1.8 \times 10^{-10} = (s)(0.17)$$
; $s = 1.1 \times 10^{-9} \text{ M}$; $(1.1 \times 10^{-9} \text{ mol/L})(143.4 \text{ g/mol}) = 1.5 \times 10^{-7} \text{ g/L}$

23. $25 \times 10^{-3} \text{ g Pb}(\text{N}_3)_2 \times \frac{1 \text{ mol}}{291.3 \text{ g}} = 8.6 \times 10^{-5} \text{ mol}$; $[\text{Pb}(\text{N}_3)_2] = \frac{8.6 \times 10^{-5} \text{ mol}}{0.100 \text{ L}} = 8.6 \times 10^{-4} \text{ mol/L}$

$$[\text{Pb}^{2+}] = 8.6 \times 10^{-4} \text{ M}$$
; $[\text{N}_3^-] = 2(8.6 \times 10^{-4} \text{ M}) = 0.0017 \text{ M}$

$$K_{sp} = (8.6 \times 10^{-4})(0.0017)^2 = 2.5 \times 10^{-9}$$

25. At 25°C , $K_{sp} = 1.7 \times 10^{-5}$. Let s = molar solubility of PbCl_2 ; $[\text{PbCl}_2] = [\text{Pb}^{2+}] = s$; $[\text{Cl}^-] = 2s$

$$1.7 \times 10^{-5} = (s)(2s)^2$$
; $s = 0.016 \text{ mol/L}$; $(0.016 \text{ mol/L})(278.1 \text{ g/mol}) = 4.50 \text{ g}$ will dissolve in 1 L.

Since only 1.0 g PbCl_2 is added, none will crystallize out.

27. $\text{Fe}(\text{OH})_2(s) \rightleftharpoons \text{Fe}^{2+}(aq) + 2\text{OH}^-(aq)$ $K_{sp} = 5 \times 10^{-17}$

$$[\text{Fe}(\text{OH})_2] = [\text{Fe}^{2+}] = s$$
 = molar solubility of $\text{Fe}(\text{OH})_2$

(a) $5 \times 10^{-17} = (s)(1 \times 10^{-10})$; $s = 5 \times 10^{-7} \text{ mol/L}$

$$(5 \times 10^{-7} \text{ mol/L})(89.87 \text{ g/mol})(0.100 \text{ L}) = 4 \times 10^{-6} \text{ g}$$

$$(b) \ 5 \times 10^{-17} = (s)(1 \times 10^{-7}) ; \quad s = 5 \times 10^{-10} \text{ mol/L}$$

$$(5 \times 10^{-10} \text{ mol/L})(89.87 \text{ g/mol})(0.100 \text{ L}) = 4 \times 10^{-9} \text{ g}$$

$$(c) \ 5 \times 10^{-17} = (s)(1 \times 10^{-4}) ; \quad s = 5 \times 10^{-13} \text{ mol/L}$$

$$(5 \times 10^{-13} \text{ mol/L})(89.87 \text{ g/mol})(0.100 \text{ L}) = 4 \times 10^{-12} \text{ g}$$

$$29. [\text{Ba}^{2+}] = [\text{Ba}(\text{OH})_2] = \frac{2.37 \text{ g Ba}(\text{OH})_2}{0.100 \text{ L}} \times \frac{1 \text{ mol}}{171.3 \text{ g}} = 0.138 \text{ M}$$

$$\text{pH} = 13.28; \quad \text{pOH} = 0.72; \quad [\text{OH}^-] = 0.19 \text{ M}$$

$$K_{\text{sp}} = [\text{Ba}^{2+}][\text{OH}^-]^2 = (0.138)(0.19)^2 = 5.0 \times 10^{-3}$$

$$31. (a) [\text{Pb}^{2+}] \text{ to precipitate } \text{PbSO}_4 = 1.8 \times 10^{-8} / 0.035 = 5.1 \times 10^{-7} \text{ M}$$

$$[\text{Pb}^{2+}] \text{ to precipitate } \text{PbCrO}_4 = 2 \times 10^{-14} / 0.035 = 5.7 \times 10^{-13} \text{ M}$$

PbCrO_4 precipitates first.

$$(b) \ 5.7 \times 10^{-13} \text{ M}$$

$$33. (a) \text{ mol Al}^{3+} = (0.40 \text{ mol/L})(0.065 \text{ L}) = 0.026 ; \quad [\text{Al}^{3+}] = \frac{0.026 \text{ mol}}{0.065 \text{ L} + 0.125 \text{ L}} = 0.14 \text{ M}$$

$$\text{mol Fe}^{2+} = (0.17 \text{ mol/L})(0.125 \text{ L}) = 0.021 ; \quad [\text{Fe}^{2+}] = \frac{0.021 \text{ mol}}{0.065 \text{ L} + 0.125 \text{ L}} = 0.11 \text{ M}$$

$$\text{OH}^- \text{ needed to precipitate Al}^{3+} \text{ as Al}(\text{OH})_3: \ 2 \times 10^{-31} = (0.14)[\text{OH}^-]^3 ; \quad [\text{OH}^-] = 1 \times 10^{-10}$$

$$\text{OH}^- \text{ needed to precipitate Fe}^{2+} \text{ as Fe}(\text{OH})_2: \ 5 \times 10^{-17} = (0.11)[\text{OH}^-]^2 ; \quad [\text{OH}^-] = 2 \times 10^{-8}$$

$\text{Al}(\text{OH})_3$ will precipitate first

$$(b) \approx 1 \times 10^{-10} \text{ M}$$

$$35. \text{ Total volume of solution} = 0.125 \text{ L} + 0.225 \text{ L} + 0.025 \text{ L} = 0.375 \text{ L}$$

$$\text{mol Au}^+ = (0.100 \text{ mol/L})(0.125 \text{ L}) = 0.0125 ; \quad [\text{Au}^+] = \frac{0.0125 \text{ mol}}{0.375 \text{ L}} = 0.0333 \text{ M}$$

$$\text{mol Ag}^+ = (0.049 \text{ mol/L})(0.225 \text{ L}) = 0.011 ; \quad [\text{Ag}^+] = \frac{0.011 \text{ mol}}{0.375 \text{ L}} = 0.029 \text{ M}$$

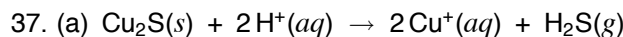
$$\text{mol Cl}^- = (0.0100 \text{ mol/L})(0.025 \text{ L}) = 2.5 \times 10^{-4} ; \quad [\text{Cl}^-] = \frac{2.5 \times 10^{-4} \text{ mol}}{0.375 \text{ L}} = 6.7 \times 10^{-4} \text{ M}$$

$$Q \text{ for AuCl} = (0.0333)(6.7 \times 10^{-4}) = 2.2 \times 10^{-5} > 2.0 \times 10^{-13}$$

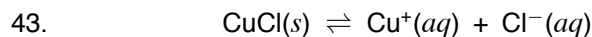
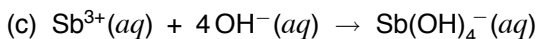
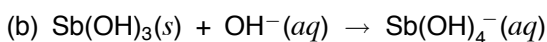
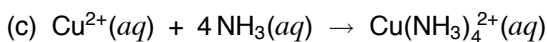
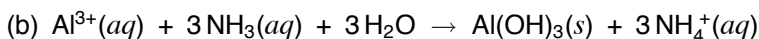
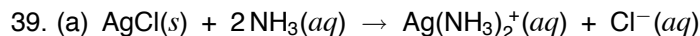
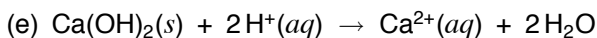
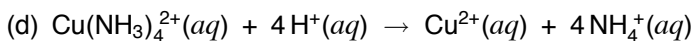
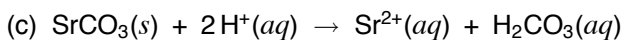
$$Q \text{ for AgCl} = (0.029)(6.7 \times 10^{-4}) = 2.0 \times 10^{-5} > 1.8 \times 10^{-10}$$

Theoretically, both AuCl and AgCl should precipitate, but mol Cl^- (2.5×10^{-4}) \ll mol Au^+ (0.0125).

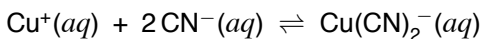
Since AuCl will precipitate first (smaller K_{sp}), it will consume all the chloride. AgCl will not precipitate.



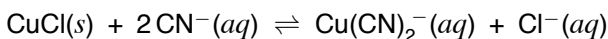
(b) no reaction



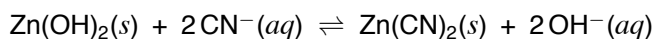
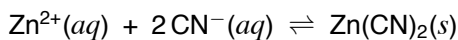
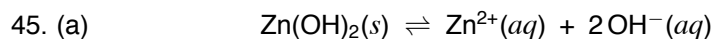
$$K_1 = K_{\text{sp}} \text{ CuCl}$$



$$K_2 = K_f \text{ Cu}(\text{CN})_2^-$$

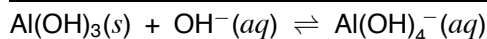
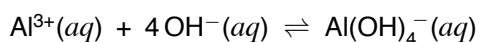
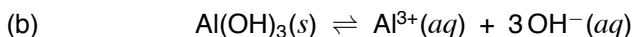
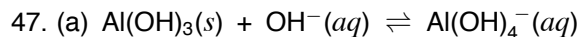


$$K = (K_{\text{sp}} \text{ CuCl})(K_f \text{ Cu}(\text{CN})_2^-) = (1.9 \times 10^{-7})(1.0 \times 10^{16}) = 1.9 \times 10^9$$



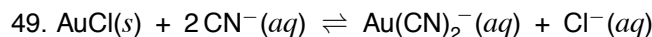
$$K = \frac{K_{\text{sp}} \text{ Zn}(\text{OH})_2}{K_{\text{sp}} \text{ Zn}(\text{CN})_2} = \frac{4 \times 10^{-17}}{8.0 \times 10^{-12}} = 5 \times 10^{-6}$$

(b) no; K (5×10^{-6}) is too small



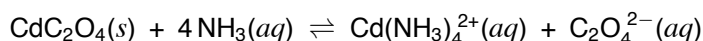
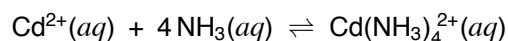
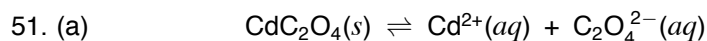
$$K = (K_{\text{sp}} \text{ Al}(\text{OH})_3)(K_f \text{ Al}(\text{OH})_4^-) = (2 \times 10^{-31})(1 \times 10^{33}) = 2 \times 10^2$$

$$(c) 2 \times 10^2 = \frac{[\text{Al}(\text{OH})_4^-]}{1 \times 10^{-2}}; \quad [\text{Al}(\text{OH})_4^-] \approx 2 M$$



$$K = (K_{\text{sp}} \text{ AuCl})(K_{\text{f}} \text{ Au}(\text{CN})_2^-) = (2.0 \times 10^{-13})(2 \times 10^{38}) = 4 \times 10^{25}$$

$$4 \times 10^{25} = \frac{[\text{Au}(\text{CN})_2^-][\text{Cl}^-]}{[\text{CN}^-]^2} = \frac{s^2}{0.010}; \quad s = 6 \times 10^{11} M \text{ (completely soluble)}$$



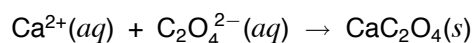
$$K = (K_{\text{sp}} \text{ CdC}_2\text{O}_4)(K_{\text{f}} \text{ Cd}(\text{NH}_3)_4^{2+}) = (1.5 \times 10^{-8})(2.8 \times 10^7) = 0.42$$

$$(b) [\text{C}_2\text{O}_4^{2-}] = [\text{CdC}_2\text{O}_4] = \frac{2.00 \text{ g}}{1.00 \text{ L}} \times \frac{1 \text{ mol}}{200.4 \text{ g}} = 0.0100 M; \quad [\text{Cd}(\text{NH}_3)_4^{2+}] = [\text{C}_2\text{O}_4^{2-}]$$

$$0.42 = \frac{[\text{Cd}(\text{NH}_3)_4^{2+}][\text{C}_2\text{O}_4^{2-}]}{[\text{NH}_3]^4} = \frac{(0.0100)^2}{[\text{NH}_3]^4}; \quad [\text{NH}_3] = 0.12 M$$

$$53. \text{mol Ca}^{2+} \text{ in blood sample} = \frac{0.10 \times 10^{-3} \text{ g}}{1 \text{ mL}} \times 250.0 \text{ mL} \times \frac{1 \text{ mol}}{40.08 \text{ g}} = 6.2 \times 10^{-4}$$

$$\text{mol C}_2\text{O}_4^{2-} \text{ in precipitating solution} = (0.160 \text{ mol/L})(0.2500 \text{ L}) = 0.0400$$



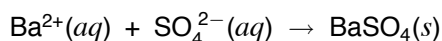
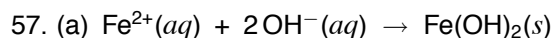
Ca^{2+} is limiting and used up.

$$\text{mol C}_2\text{O}_4^{2-} = 0.0400 - 6.2 \times 10^{-4} = 0.0394; \quad [\text{C}_2\text{O}_4^{2-}] = \frac{0.0394 \text{ mol}}{0.250 \text{ L} + 0.250 \text{ L}} = 0.0788 M$$

$$4 \times 10^{-9} = [\text{Ca}^{2+}][0.0788]; \quad [\text{Ca}^{2+}] = 5 \times 10^{-8} M$$

$$55. [\text{F}^-] = \frac{2.0 \text{ g}}{10^3 \text{ L water}} \times \frac{1 \text{ mol}}{19.0 \text{ g}} = 1.1 \times 10^{-4} M$$

$$Q = (3.5 \times 10^{-4})(1.1 \times 10^{-4})^2 = 4.2 \times 10^{-12} < K_{\text{sp}} \text{ CaF}_2 (1.5 \times 10^{-10}); \quad \text{no}$$



$$(b) \text{ mol Fe}^{2+} = \text{mol SO}_4^{2-} = \text{mol FeSO}_4 = (0.0250 \text{ L})(0.500 \text{ mol/L}) = 0.0125$$

$$\text{mol Ba(OH)}_2 = \text{mol Ba}^{2+} = (0.0350 \text{ L})(0.332 \text{ mol/L}) = 0.0116 ; \quad \text{mol OH}^- = 2(\text{mol Ba}^{2+}) = 0.0232$$

For Fe(OH)_2 precipitation: OH^- is limiting and 0.0116 mol Fe(OH)_2 are formed.

$$\text{mass Fe(OH)}_2 = (0.0116 \text{ mol})(89.87 \text{ g/mol}) = 1.04 \text{ g}$$

For BaSO_4 precipitation: Ba^{2+} is limiting and 0.0116 mol BaSO_4 are formed.

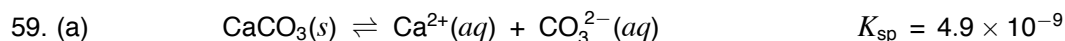
$$\text{mass BaSO}_4 = (0.0116 \text{ mol})(233.4 \text{ g/mol}) = 2.71 \text{ g}$$

$$(c) \text{ mol SO}_4^{2-} \text{ unreacted} = 0.0125 - 0.0116 = 9.00 \times 10^{-4} ; \quad [\text{SO}_4^{2-}] = \frac{9.00 \times 10^{-4} \text{ mol}}{0.0350 \text{ L} + 0.0250 \text{ L}} = 0.015 \text{ M}$$

$$1.1 \times 10^{-10} = [\text{Ba}^{2+}][\text{SO}_4^{2-}] = [\text{Ba}^{2+}](0.015) ; \quad [\text{Ba}^{2+}] = 7.3 \times 10^{-9} \text{ M}$$

$$[\text{Fe}^{2+}] = [\text{SO}_4^{2-}] = 0.015 \text{ M}$$

$$5 \times 10^{-17} = [\text{Fe}^{2+}][\text{OH}^-]^2 = (0.015)[\text{OH}^-]^2 ; \quad [\text{OH}^-] = 6 \times 10^{-8} \text{ M}$$



$$(b) \text{ Let } s = [\text{CaCO}_3] ; \quad [\text{CaCO}_3] = [\text{Ca}^{2+}] = [\text{CO}_3^{2-}] = s$$

$$4.9 \times 10^{-9} = (s)(s) ; \quad s = 7 \times 10^{-5} \text{ M}$$

$$(c) 1.0 \times 10^2 = \frac{[\text{Ca}^{2+}][\text{HCO}_3^-]}{[\text{H}^+]} ; \quad [\text{CaCO}_3] = [\text{Ca}^{2+}] = [\text{HCO}_3^-] = s$$

$$1.0 \times 10^2 = \frac{(s)(s)}{1.0 \times 10^{-4}} ; \quad s = 0.10 \text{ M}$$

61. 7 \square , 7 \bigcirc in solution

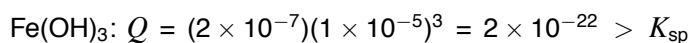
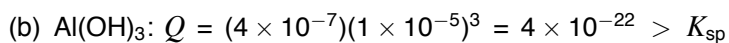
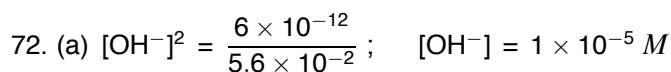
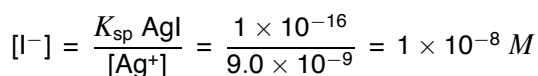
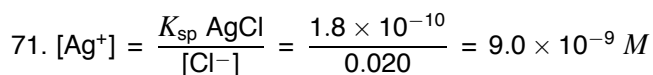
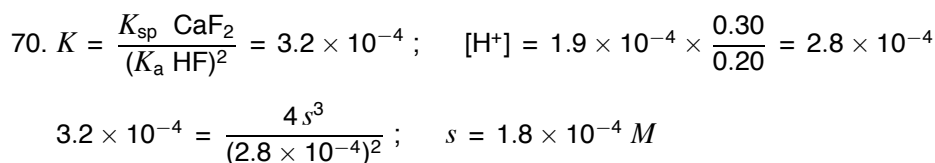
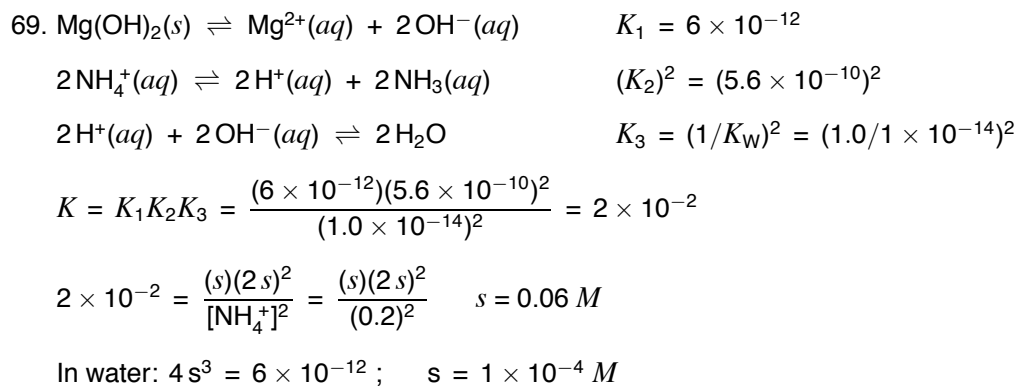
63. 4 \square , 8 \bigcirc in solution, 2 $\bigcirc\square\bigcirc$ at bottom

65. (a) JQ	$s^2 = 1 \times 10^{-10}$	$s = 1 \times 10^{-5}$	
K ₂ R	$4s^3 = 1 \times 10^{-10}$	$s = 3 \times 10^{-4}$	
L ₂ S ₃	$108s^5 = 1 \times 10^{-10}$	$s = 4 \times 10^{-3}$	greatest molar solubility
MT ₂	$4s^3 = 1 \times 10^{-10}$	$s = 3 \times 10^{-4}$	
NU ₃	$27s^4 = 1 \times 10^{-10}$	$s = 1 \times 10^{-3}$	

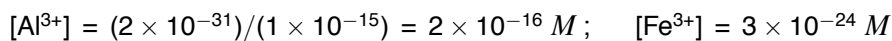
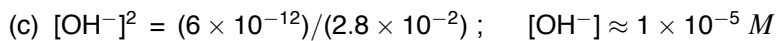
(b) can't tell without molar mass

(c) no; don't know molar mass

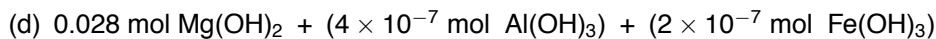
67. (a) T (b) T (c) F (d) T (e) T



Al(OH)_3 and Fe(OH)_3 precipitate.



virtually all

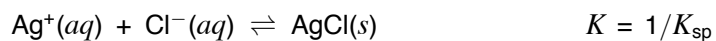
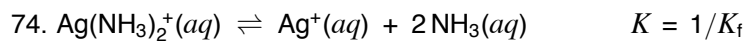


$(0.028 \text{ mol})(58.32 \text{ g/mol}) = 1.6 \text{ g}$

$$73. (a) K = \frac{K_f \text{Zn(OH)}_4^{2-}}{K_f \text{Zn(NH}_3)_4^{2+}} = \frac{3 \times 10^{14}}{3.6 \times 10^8} = 8 \times 10^5$$

$$(b) \text{ In } 1.0 M \text{ NH}_3: [\text{OH}^-] = 4.2 \times 10^{-3} M$$

$$\frac{\text{Zn(OH)}_4^{2-}}{\text{Zn(NH}_3)_4^{2+}} = \frac{(8 \times 10^5)(4.2 \times 10^{-3})^4}{(1.0)^4} = 2.6 \times 10^{-4}; \quad \frac{\text{Zn(NH}_3)_4^{2+}}{\text{Zn(OH)}_4^{2-}} = 4 \times 10^3$$



$$K = \frac{1}{K_f (K_a)^2 K_{sp}} = 1.0 \times 10^{21}$$